

Investigation of behavioral methods for improving crew alertness, motivation, and performance and reducing malaise is recommended. The value of utilizing three separate converging indicators—physiological measures, performance measures, and standardized symptom reports—has been demonstrated as an effective means of assessing

environmental impacts on the safety and well-being of human passengers or crew on land, sea, air, and space vehicles.

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## Virtual Environment Surgery and the Virtual Hospital

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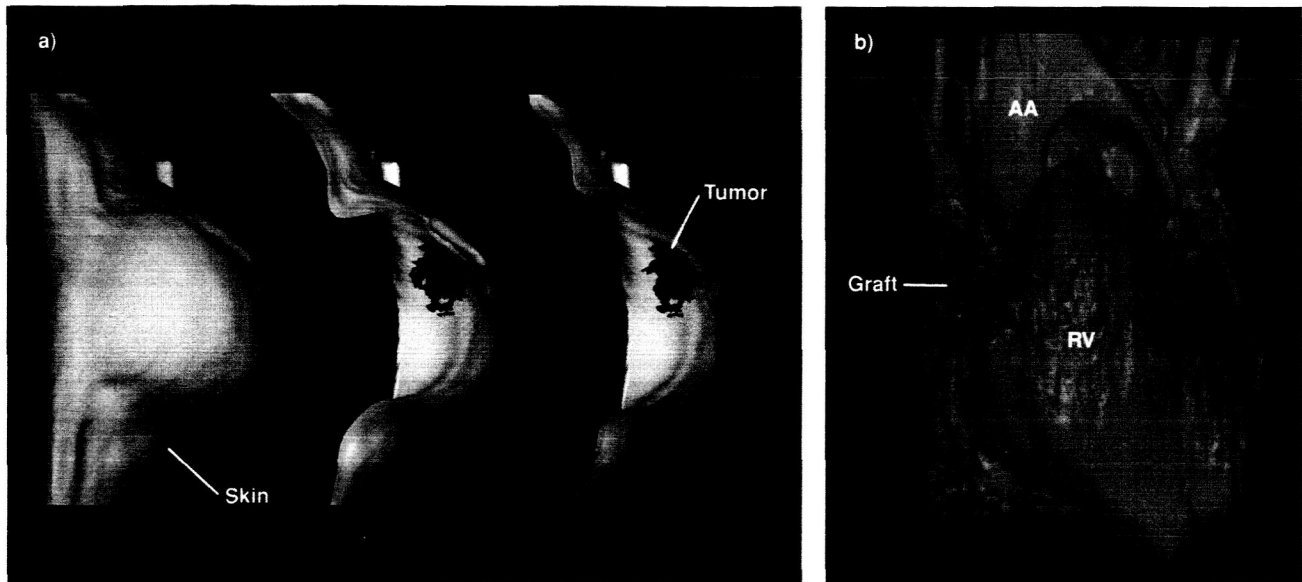
The Biocomputation Center is dedicated to computer-based three-dimensional (3-D) visualization, mathematically based modeling, and 3-D simulation. The emphasis is on teams of broadly based, interdisciplinary investigators, and on a union between computational, theoretical, and experimental research. Virtual environment surgery (VES) technologies of the Biocomputation Center have found several new applications in FY97, including breast cancer imaging research and 3-D ultrasound and computed tomography (CT) visualization tools. In addition, the first steps have been taken toward creating a virtual hospital, linking several clinical institutions using the VES technology and the Next Generation Internet/NASA Research and Education Network (NGI/NREN).

The Biocomputation Center maintains state-of-the-art virtual environment technologies for 3-D viewing and interaction. The Fakespace Immersive Workbench (Fakespace, Mountain View, California) acts as a viewing interface into a virtual environment. The workbench is large and permits several individuals to see the visualization projected above the tabletop in 3-D. Special Crystal Eyes glasses (Stereographics, San Ramon, California) are required for 3-D viewing. Users have full control of viewing angle, position, and perspective. The Fakespace Pinch Glove, in conjunction with a Polhemus radio-tracking device (Framingham, Massachusetts), allows the user to interact with the virtual environment by grabbing and moving objects. The Immersive Workbench, associated hardware, and the VES software are driven by a Silicon Graphics Onyx RE2 workstation.

The Ames Biocomputation Center has a long history of success in processing, manipulation, and visualization of large 3-D biological datasets. In FY97, with the permission of the Stanford Radiology Group, the VES technologies were applied to magnetic resonance imagery (MRI) of breast cancer for visualization, modeling, and virtual environment surgery applications as shown in part (a) of the first figure. Women's health issues are of increasing importance to NASA now that one half of future astronauts will be women. This new research effort improves upon previous methods for breast cancer visualization, and will help to model the motion of the tumor within the breast as a woman's body shifts during diagnosis and surgery. In addition, emerging methodologies resulting from this breast cancer imaging application will apply directly to NASA's interests in other MRI, Ultrasound, and Space applications.

The Biocomputation Center has used its specialized VES software and computing facilities to process 3-D datasets of the heart. A post-operational CT scan of the heart showing a graft was visualized using the same software as shown in part (b) of the figure. In the future, this segmentation and visualization technology will be applied to 3-D ultrasound datasets from the Cleveland Clinic Foundation, Department of Cardiovascular Imaging.

Today, there is a need for a collaborative virtual environment to perform interactive surgical planning, practice, and education activities. The Biocomputation Center has begun the process of creating a virtual hospital to connect Stanford University



*Fig. 1. Research and technology development at the Biocomputation Center in FY97 have found new imaging applications in breast cancer research and cardiology. A three-dimensional cut-away image of the breast (a) made from magnetic resonance imaging data shows a large tumor under the surface of the skin. A three-dimensional heart image (b) made from computed tomography data displays a graft from the aorta (AA) to the muscle of the right ventricle (RV).*

Medical School, The Cleveland Clinic Foundation, and the Salinas Valley Memorial Hospital. The VES technologies will be used to process raw data, and to provide an interactive work environment between institutions. Through these interactive sessions, doctors will be able to discuss diagnoses, share preoperative planning strategies and techniques, or even perform "virtual surgeries" as a group, thus linking experts across the globe in an unprecedented way.

The virtual environment technology will be useful to the Human Exploration and Development of Space (HEDS) Enterprise for training astronauts for long-term missions in space. It will provide simula-

tion capability during spaceflight to help astronauts respond appropriately to unanticipated emergencies. Advances in telemedicine and collaborative virtual environment tools developed for the Virtual Hospital will lay the groundwork for interaction between people on Earth and in Space. Today, Ames Research Center and the Biocomputation Center are poised to take a leading role in 3-D imaging technologies for both Earth-bound and space-based applications.

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